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Brief report

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Teeth of multituberculate mammals from the Late Cretaceous of Romania

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Remains of multituberculates are very rare in Upper Cretaceous deposits of Europe, being described only from the upper Maastrichtian Sînpetru Formation, Haţeg Basin, Romania. New excavations undertaken in the coeval Densuş–Ciula Formation from Haţeg led to the recovery of a few isolated multituberculate teeth, which we describe herein. At least some of these teeth belong to *Hainina* Vianey-Liaud, 1979, a poorly known Paleocene genus from western Europe.

While multituberculates represent an important component of most North American and Asian Late Cretaceous continental vertebrate assemblages (Clemens & Kielan-Jaworowska 1979), they are almost completely absent from contemporary European deposits. The most thoroughly sampled western European localities have, thus far, yielded only very rare therian teeth; these come from scattered sites in France and the Iberian Peninsula (see, e.g., Gheerbrant & Astibia 1999 and references therein).

An isolated I2 from Sînpetru was assigned to an indeterminate multituberculate by Grigorescu (1984). At Pui, the lowermost part of the Sînpetru Formation yielded two multituberculate molars, associated with a diverse assemblage of fishes, amphibians and reptiles (Grigorescu *et al.* 1985). One of these teeth, a right M1, was designated as the holotype of *Barbatodon transylvanicum* Rădulescu & Samson, 1986. The same specimen was later interpreted as a left m1 and formed the basis for the taxon *Paracimexomys? dacicus* Grigorescu & Hahn, 1987. The second specimen, a m2, is indeterminate. More recently discovered lower incisors document the presence of two different multituberculate groups in the uppermost Cretaceous of Haţeg (Rădulescu & Samson 1997). Finally, in a preliminary report the taxon *Kogaionon ungureanui* Rădulescu & Samson, 1996 was erected, on the basis of a nearly complete skull without dentaries.

Recent fieldwork in the Densuş-Ciula Formation (in the northwestern part of the Haţeg Basin), of roughly the same age as the Sînpetru Formation, has led to the identification of two new fossil mammal localities (Fig. 1). An isolated multituberculate I2 was recovered from the Tuştea dinosaur nesting site, in a microvertebrate assemblage that includes frogs, albanerpetontids, turtles, crocodilians and dromaeosaurid theropods. Most of the new specimens come from the Fântânele microvertebrate fossil site near Vălioara. This locality has yielded a diverse assemblage of fishes, anurans, albanerpetontids, chelonians, lacertilians, crocodilians, theropod, sauropod and ornithopod dinosaurs, pterosaurs and multituberculates, besides characeeans, ostracods, gastropods, pelecypods and eggshell fragments. The multituberculates are represented by isolated, usually well-preserved teeth, including i1, p4, m1, P1, and P3?. The specimens are housed at the Faculty of Geology and Geophysics, Bucharest University in Bucharest, abbreviated FGGUB.

Description

I2. — The crown of the right I2 (FGGUB M.1609; Fig. 2A) is transversely compressed. It shows a large anterior and a smaller posterior cusp; both have worn tips, so that the relative degree of development of the posterior cusp cannot be correctly assessed. The base of the accessory cusp is confluent with that of the main cusp on the lingual side, while labially they are separated by a wide and shallow groove. The

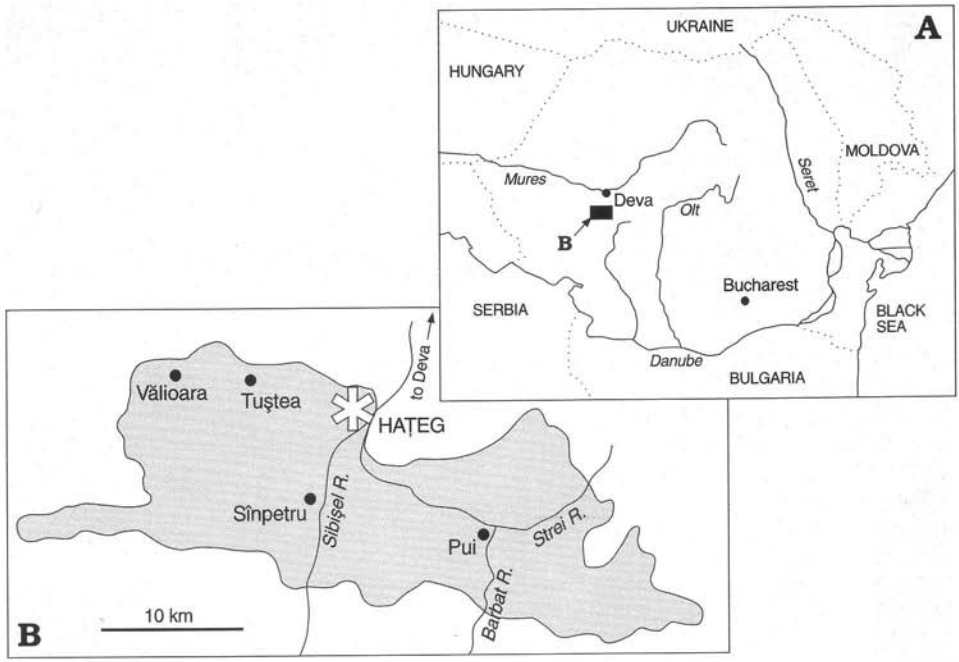

Fig. 1. Late Maastrichtian multituberculate localities from the Haţeg Basin.

anterior cusp is recurved; its tip and lingual side are heavily worn, while the slightly angular labial side is intact. The accessory cusp is also worn; the wear facet is flat, lingually slightly dipping and confluent with that of the main cusp. The crown is completely covered with enamel of uniform thickness.

P1. — The first premolar is represented by two well-preserved crowns (FGGUB M.1610, Fig. 2B, D; and FGGUB M.1611, Fig. 2C, E). They have similar morphologies, although minor differences exist in dimensions (length and width are 1.01 × 0.92 and 1.03 × 0.99 mm, respectively, for the two specimens), shape and proportions. The crown is bulbous and oval to sub-circular. There are two conical cusps of about the same size, separated by a deep and wide valley. The occlusal face is slightly asymmetric, as the line uniting the two cusps divides the crown into two unequal parts, while the long axis of the crown is oblique to this line. It is rather uncertain whether the cusps are placed longitudinally, transversely or obliquely relative to the antero-posterior axis of the crown. We suspect they might have formed a transversely oblique row. The cusps are ornamented with radiating ridges. The roots are broken; their number is unknown.

P3?. — A possible P3 is represented by a fragment (FGGUB M.1614, Fig. 2F) showing a large and a small conical cusp, as well as part of a third one. The root region is missing.

i1. — The crown of a left i1 (FGGUB M.1612, Fig. 3) is elongate and very gently curved. It slightly tapers distally and is worn at the tip, exposing the dentine. The tooth is fully enamel covered: the enamel is reduced dorsally and lingually, with a clearly marked limit on the lingual aspect. The transversal cross-section of the tooth is roughly triangular; the dorsolingual edge is more angular than the dorsolabial and ventral edges; the dorsal face is almost flat. Both the labial and lingual sides present a wide and shallow longitudinal groove, the lingual one being more marked.

p4. — FGGUB M.1615 represents the anteriormost part of a right p4 (Fig. 2G). It shows a small basal notch for p3 and a cusp-like first serration without descending ridge; the anterior margin is largely rounded. Two weakly defined ridges, parallel to the anterior margin, stop well above the base of the crown in lingual view.

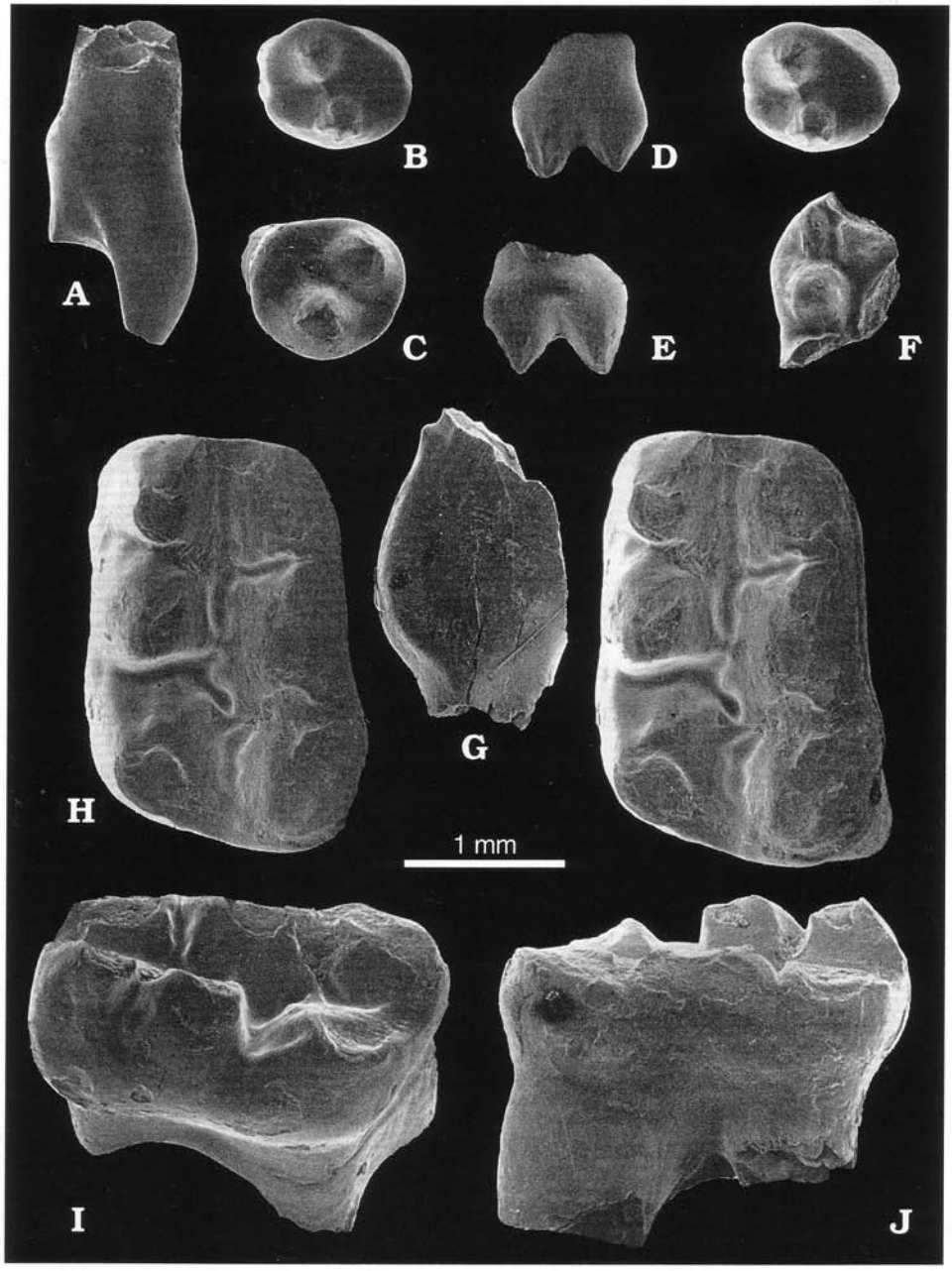

Fig. 2. Multituberculate teeth, Maastrichtian, Densuş-Ciula Formation, Tuştea (**A**) and Vălioara (**B–J**), Haţeg Basin. All specimens are from FGGUB collection. **A** – indeterminate right I2 (M.1609) in labial view. *Hainina* sp. A, P1 (M.1610) in occlusal (**B**) and side (**D**) view. P1 (M.1611) in occlusal (C) and side (**E**) view. **F**. ?*Hainina* sp. P3 (M.1614) in occlusal view. **G**. ?*Hainina* sp. right p4 (M.1615) in lingual view. *Hainina* sp. B, right m1 (M.1613) in occlusal (**H**), oblique postero-lingual (**I**), and labial (**J**) view. All are SEM micrographs, **B** and **H** are stereo-pairs.

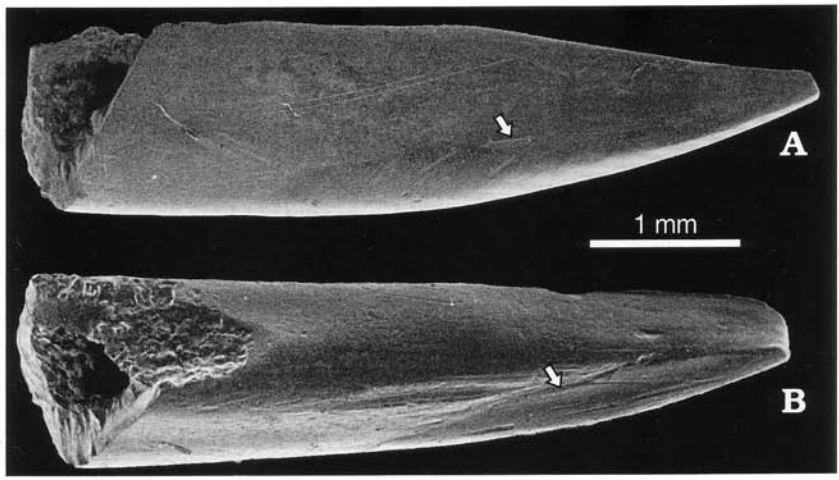

Fig. 3. Indeterminate multituberculate, i1 (FGGUB M.1612), Maastrichtian, Densuş-Ciula Formation, Vălioara, Haţeg Basin. A – lingual and B – dorso-lingual view. Arrow points to the line delimiting the thicker enamel band.

m1. — The right m1 (FGGUB M.1613; 2.67 × 1.96 mm, Fig. 2H–J) is roughly rectangular in occlusal view, with the lateral and medial sides parallel anteriorly; posteriorly, the lateral side bulges labially. The cusp formula is 3:3; the cusps are pyramidal. In the labial row, the cusps are heavily worn, the degree of wear increasing anteriorly. The first cusp is smaller than the second one; the latter is well separated from the third one. This latter shows a tendency toward a twofold division. The lingual row has taller cusps than the labial row; the first two cusps show wear facets only on their labial side, while the third one is heavily worn. The first two cusps are sub-equal, the third one is larger and separated by a wide and deep valley from the second. The longitudinal valley separating the cusp rows is slightly undulating; ridges descend toward this valley from the second and third cusps in both rows.

Discussion

Documenting that isolated multituberculate teeth are conspecific is a difficult task and is generally based on absolute and relative sizes, appropriate ratios of dimensions, fit of contacting facets, frequency of occurrence within sites, and morphology of cusps (see e.g., Eaton 1995). This requires large samples, unfortunately unavailable in the present context. Consequently, the teeth from Haţeg are discussed separately.

Bicusped upper premolars occur rarely in multituberculates. The first premolars are the simplest ones in the upper tooth row, but they bear three or four cusps in virtually all basal as well as in most advanced multituberculates (Clemens & Kielan-Jaworowska 1979). Among cimolodontans, a bicusped P1 was described in the Thanetian (late Paleocene) *Hainina godfriauxi* from Cernay, France, by Vianey-Liaud (1986: fig. 15a–b), a taxon otherwise known from the Montian (middle Paleocene) of Belgium (Vianey-Liaud 1979). P1 of *H. godfriauxi* is similar to the Haţeg P1s in having two well-developed, conical cusps separated by a deep valley, the same pattern of asymmetry, and ornamentation consisting of radiating ridges. However, it is larger (1.76 × 1.42 mm) than either FGGUB M.1610 or M.1611. The P1 of the genotype *H. belgica,* from the Montian of Hainaut, has three cusps (Vianey-Liaud 1979: fig. 3), being somewhat larger still (at least 1.25 × 0.97 mm) than P1s from Haţeg. Taking into account the overall morphological similarity to the P1 of *H. godfriauxi*, the Fântânele P1s are assigned to *Hainina*.

The m1 (FGGUB M.1613) has a low cusp count (3:3), unmatched by any other known Late Cretaceous multituberculate. Similar cusp formulae are reported in the Upper Jurassic allodontids *Ctenacodon* and *Psalodon*. Cimolodontan m1s usually have a cusp formula of 5:4 or higher, except-

ing *Paracimexomys* and related forms (e.g., Eaton 1995), most djadochtatherians (Kielan-Jaworowska & Hurum 1997), as well as *Hainina*. Among these, members of the *Paracimexomys* group and djadochtatherians have a minimal cusp formula of 4:3, and only the Montian species of *Hainina* has a cusp count of 3:3. Similarity in morphological details of FGGUB M.1613 to m1 of *Hainina* (for comparison see Vianey-Liaud 1979: p. 126) suggest that it might indeed belong to this genus. Therefore, it is referred to *Hainina*. It is larger than the m1s assigned to *H. belgica*, and comparable in size to that of *H. godfriauxi* from Hainin.

The conspecifity of m1 and P1s cannot be established until more complete material is found. However, it is noteworthy that FGGUB M.1613 ranks among the largest m1s known for *Hainina*, while FGGUB M.1610 and FGGUB M.1611 have dimensions below the size range of the previously described P1s of *Hainina*. Consequently, it is improbable that they belong to the same taxon and thus are allocated to two different species, as *Hainina* sp. A (FGGUB M.1610, M1611) and *Hainina* sp. B (FGGUB M.1613).

The question of whether these teeth may belong to formerly known multituberculate taxa from Haţeg, *Barbatodon transylvanicum* and *Kogaionon ungureanui*, instead of *Hainina*, must also be addressed.

P1 of *Kogaionon ungureanui* is tricusped, unlike the P1s from Vălioara. Moreover, these latter do not belong to *Barbatodon transylvanicum* either, as the holotype molar is much larger (3.4 mm long) than expected for such tiny P1s. Consequently, *Hainina* sp. A stands as a taxon separate from those previously described from Haţeg.

Whether the m1 (FGGUB M.1613) belongs to either of the formerly described taxa is more difficult to determine. If it indeed belongs to *Hainina*, then, by comparison with the Paleocene species of the genus, one might consider that its corresponding M1 might have had a morphology comparable to those of these species; but M1s of *H. belgica* (cusp count 4:4:7) or *H. godfriauxi* (cusp count 3–4:4:4–7, mean 3:4:5), both with complete lingual rows, are strikingly different from M1 of *Barbatodon transylvanicum* (3:4:ridge). This provides some reasonable basis for recognizing *B. transylvanicum* and *Hainina* sp. B as distinct taxa.

On the other hand, comparison of the reconstructed upper dentition of *Hainina* (Vianey-Liaud, 1979) with that of *Kogaionon ungureanui* suggests a possible relationship between the two taxa. Similarities include the presence of three complete cusp rows in M1, small number of cusps in the labial (3–4) and medial (4) rows, premolar cusp formulae, etc.

Be that as it may, the m1 of *Kogaionon ungureanui* (based on analogy with *Hainina*) may have had the same morphology as FGGUB M.1613. The much larger relative size of the only known M1 of *K. ungureanui* (length of m1 to length of M1 ratio = 0.685), when compared to that in *H. belgica* (ratio 0.809) or in *H. godfriauxi* (mean ratio 0.896, variation 0.868–0.902), indicate, despite of the reduced number of specimens concerned, that our m1 (FGGUB M.1613) does not belong to *K. ungureanui*. Consequently, its allocation to another taxon (*Hainina*) seems warranted.

Despite the fragmentary nature of p4 (FGGUB M.1615), it is reminiscent of the p4 of *Hainina* (only known in *H. belgica*) in anterior profile, with weakly defined ridges parallel to the anterior margin, and a small notch for p3. The ratio of its size relative to that of the Haţeg P1s is comparable to the ratio seen in *H. belgica*, suggesting that FGGUB M.1615 may also belong to *Hainina* sp. A.

The i1 (FGGUB M.1612) is generally of ptilodontoid pattern, adapted for puncturing and grasping. Similar incisors, with labially thick, lingually thin enamel are present in some djadochtatherians (e.g., *Sloanbaatar*, *Kamptobaatar*, and *Nessovbaatar*; Kielan-Jaworowska & Hurum 1997). In many taxa (including *Hainina*), however, the i1 is unknown. Rădulescu & Samson (1997) described a comparable tooth from Pui; it differs from FGGUB M.1612 by being more markedly tapered in dorsal view.

The poor preservation of P3 does not allow detailed comments. However, it may belong to either of these two new taxa, as all teeth from Fântânele were recovered through processing of a small amount (200 kg) of sediments, sampling a 20 cm thick × 1.5 m long interval.

The isolated I2 from Tuştea has two character states plesiomorphic for the Multituberculata: full enamel cover and a bicusped crown. Most members of the Late Jurassic–Early Cretaceous Plagiaulacoidea have bicusped, fully enamel-covered I2s, but in the Late Cretaceous–Paleogene Cimolodonta

bicusped I2 occurs only in Eucosmodontidae, *Meniscoessus* and *Catopsalis*. Grigorescu (1984) reported on a similar I2 from the Sînpetru Formation. It does not belong to *Kogaionon ungureanui*, in which I2 has reduced enamel; the I2 is not known for *Hainina*. For the moment, FGGUB M.1609 is considered as indeterminate cimolodontan.

The new finds from Haţeg document the presence of the Paleocene genus *Hainina*, with two different species, as well as that of an indeterminate cimolodontan in the late Maastrichtian continental vertebrate assemblages from Romania, considerably increasing the multituberculate diversity recorded from the Maastrichtian of Europe.

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